

## Digital Manufacturing and Design Innovation (DMDI) Institute

**Need:** U.S. manufacturing requires speed to market to gain an advantage in global competitiveness. The 'digital thread' that integrates and drives modern design, manufacturing and product support processes can be exploited to reduce cycle time and achieve first pass success, and is the only feasible way to deal with constantly increasing complexity in products and manufacturing enterprises. Visions of the factory-of-the-future have many different names (advanced manufacturing enterprise, intelligent manufacturing systems, smart manufacturing, industrial internet, etc.) but a common understanding that the key to success is networked, data-driven processes that combine innovative automation, sensing and control with a transformed manufacturing workforce at every level – from the shop floor to the factory control level to the global supply chain. Realizing this vision requires pre-competitive collaboration on many fronts, and the DMDI Institute will be focused on maturing the digital thread for applications in manufacturing and design of electro-mechanical assemblies and systems. This is of significant interest not only to defense but also to most commercial industrial sectors (including aerospace, transportation and energy) due to increasing levels of complexity, integration and cost. Examples include power train, propulsion and structural components, as well as control subsystems and systems. The DMDI Institute will provide the proving ground to link promising information technologies, tools, standards, models, sensors, controls, practices and skills, and then transition these capabilities to the industrial base for full-scale application. The Institute will meet the need for cross-disciplinary teams to integrate IT and manufacturing solutions, and multi-industry collaboration to promote interoperability in supply chains. The Institute will be the intellectual hub that helps U.S. manufacturers be the best in the world at connecting their flexible manufacturing operations, driving them securely with digital data, controlling quality with feedback from sensors and data analysis, maintaining a trusted chain of custody and delivering products in significantly less time than global competitors.

**National Economic Impact:** The DMDI Institute will raise the global competitiveness of U.S. small and medium sized manufacturers by smart and comprehensive use of the 'digital thread' throughout design, production and support, thereby erasing any competitive advantage from low cost, low skill labor. One strength of the DMDI approach is that results will be applicable to nearly every manufacturing industry sector and are expected to decrease costs by roughly 10 percent across the manufacturing enterprise – not simply for one technology or manufacturing process. Industry has analyzed major economic sectors for potential benefit by implementing a DMD environment in which every machine, facility and fleet is intelligently connected. Projected savings in commercial aviation alone is \$30B over 15 years, for example, when each major engine subsystem has the built-in intelligence to predict its performance over its lifetime. Fleet readiness can be more efficiently planned and part manufacturing can be more effectively managed. DoD and other economic sectors share similar business cases and opportunity for strong returns on investment.

**DoD Investment Rationale:** The DoD has an enormous stake in ensuring that U.S. manufacturing evolves into a more agile, connected, collaborative and efficient industry. The department requires complex, highly integrated systems to gain technological advantage, but it lacks the open market or volume to push costs or cycle times lower. Proving and progressing intelligent electro-mechanical design and manufacturing capabilities from laboratory to prototype factory environments would deliver commercial production efficiencies at lower DoD production rates and reduce the pre-final design missteps that greatly increase time and cost approaching the production decision milestone in the defense acquisition system process.

The DMDI Institute will help drive a paradigm shift in the development, production and sustainment of complex weapon systems by reducing acquisition lead time and costs through the application of digitally

networked and synchronized processes and tools that result in an open and highly collaborative environment. The Institute will also establish and integrate processes that sustain and enhance retention of supply chain knowledge and improve capacity and capability of both the organic and commercial industrial bases to affordably produce low volume, varying demand, complex systems for the DoD in support of national security.

**Description of Activities:** For the Institute to be a resource for industry that reduces the risk of adoption and provides a pathway for commercialization of new technologies, it must address both technology advancements specific to intelligent digital manufacturing and those that cut across all advanced manufacturing initiatives. The technology areas that are cross-cutting to all advancement initiatives include the ability to demonstrate the technologies in a representative environment, the development of materials and opportunities for upgrading the skills of the workforce to support the new technology in the marketplace, and ensuring the cyber physical security of the network and information. Technology advancements specific to the domain of intelligent electro-mechanical design & manufacturing include the following:

- **Advanced Manufacturing Enterprise:** This encompasses agile and robust manufacturing strategies & integrated capabilities that dramatically reduce the cost and time of producing complex systems and parts. This includes the development and implementation of modeling and simulation tools to allow faster time to market and efficient production of complex systems. It also includes a focus on tools and practices to minimize multiple designs, prototypes and test iterations typically required for product or process qualification, all connected via the ‘digital thread’ to enable designer, analyst, manufacturer, and maintainer collaboration.
- **Intelligent Machines:** This involves the development and integration of smart sensors, controls, and measurement, analysis, decision and communication software tools for self-aware manufacturing providing continuous improvement and sustainability. Intelligent machines realize the “first part correct” philosophy by allowing equipment plug-and-play functionality and allowing equipment to use manufacturing knowledge while planning and processing components, including ‘big-data’ analytics.
- **Advanced Analysis:** This area capitalizes on advances in high-performance computing to develop physics-based models of material performance with ‘design for manufacturing’ in mind. This includes developing and integrating smart design tools to help reduce over-design in order to reduce manufacturing cost.
- **Cyber Physical Systems Security:** The institute will also focus on methods and technologies to provide a secure and trusted infrastructure for the management of information assets in a highly collaborative manufacturing environment. In addition to the known vulnerabilities of networked business systems and transactions used in manufacturing, the factory of the future needs to address the new vulnerabilities of cyber physical systems in intelligent machines, sensors and control systems.

**Some Progress – But Much More is Needed.** There are examples of islands of success in the development and application of the ‘digital thread’ to the industrial base in the U.S. Even so, significant hurdles exist to the integration of intelligent electro-mechanical design and manufacturing across the defense and broader U.S. commercial industrial enterprises. Hurdles include establishing true interoperability, the effective and balanced management of intellectual property interests, maintaining network technology and security, as well as advancing machine intelligence, workforce skills, and new organizational cultures that embrace and leverage the ‘digital thread’ to maximize U.S. industrial competitiveness.